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## EXPERIMENTS IN WATER SOFTENING WITH A ZEOLITE-LIKE SUBSTANCE<sup>1</sup>

BY ROBERT N. KINNAIRD<sup>2</sup>

The application of the chemical exchange properties of zeolites to the art of water softening indicates an important step in the evolution of the art. The peculiar ability of zeolites to exchange their alkaline bases has been known for a number of years. Dr. Robert Gans of the Royal Prussian Geological Institute has been the foremost investigator of this group of minerals, and is probably the first to conceive of their applicability to water purification. Dr. Gans and others have measured the exchange capacity of a large variety of natural zeolites, and concluded that the natural deposits were either too rare or too greatly associated with impurities to be of commercial value in themselves. He therefore sought to develop a synthetic product having as large an exchange capacity as possible. His product is beginning to be fairly well known in this country and is coming into extensive commercial use abroad.

You are probably acquainted with the general nature of the process. The synthetic product, in chemical composition, is a hydrous aluminum silicate in combination with sodium. A hard water containing calcium and magnesium salts in contact with this material exchanges its calcium and magnesium ions for the sodium ions in the silicate, the result being that the medium is transformed to a calcium silicate, and the salts carried by the water become sodium salts in combination with the original acid radicals. After the silicate has absorbed its capacity of lime and magnesia, it is restored to its original sodium condition by forcing the action in the opposite direction through the agency of a solution of salt or sodium chloride. Under such conditions as are favorable this artificial product is the basis of an ideal process. Salt is cheap. The chemical application is automatic in so far that fluctuating hardness is self-adjusting.

<sup>1</sup> Read before the Iowa Section of the American Water Works Association, Iowa City, Iowa, December 3, 1915.

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No precipitation of insoluble salts is involved, consequently there is no insoluble sludge of which to dispose. Sedimentation and filtration are eliminated.

The natural substance, which the writer has been investigating, is a hydrous aluminum silicate in combination with calcium, which is capable of exchange for sodium in the raw state at a high rate and to at least as high a capacity as the synthetic product. The writer has succeeded in evolving a method of measurement of the rates of exchange in both directions of the reaction with considerable reliability and accuracy.

Des Moines city water which has a total carbonate and sulphate hardness of over 300 parts per million has been softened in experimental filters. In the laboratory of Dr. Edward Bartow of the Illinois State Water Survey these Des Moines experiments have been duplicated with the University of Illinois water having a total carbonate hardness of 300 parts per million.

With a filter layer 2 feet in thickness, rates of filtration of 2 gallons per minute per square foot and upwards have been obtained with water of 300 parts per million hardness. This is equal to the rapid sand filtration rates and suggests the substitution of this natural medium either in gravity or pressure filters for municipal use. The requirements for containers and drainage and washing systems would not be unlike the arrangement for rapid sand filtration. More idle time would be involved in the regenerating process than is at present consumed in washing the filters which would increase somewhat the bulk of the equipment. The cost per unit capacity would therefore be somewhat more than the cost of rapid sand filters. The other items of expense would be in the cost of the medium as compared with sand, its life and the cost of salt for regeneration. It is not unlikely that the medium can be produced very cheaply, as compared with a synthetic product. The material with which the writer has experimented requires some refining and hardening to give it mechanical form. The process is not involved and if handled in large quantities can be made to meet a heavy demand at an easily practicable figure.

Present information indicates that 4 pounds of salt can be counted upon to completely convert 1 pound of equivalent calcium carbonate to sodium carbonate, and the writer feels justified in saying that the indications are that this can be reduced. Assuming a ratio of 4 to 1, and 300 parts per million hardness, 10 pounds of salt would be

required to treat 1000 gallons of water. Salt is marketed in car-load lots at \$3 and upwards per ton. Assuming \$5 per ton, the chemical cost would be  $2\frac{1}{2}$  cents per 1000 gallons which is easily competitive with lime and soda.

The two processes, however, are not strictly comparable. The zeolite process gives a completely softened water without reducing the total solids. The lime process reduces the hardness by the amount of bicarbonates, while the soda process is only useful in that it converts calcium and magnesium sulphates to the sodium sulphates, which is exactly the same chemical substitution as is made by the zeolite. Either alone or in combination with lime, the zeolite process will be a most valuable finishing process. For waters harder or softer than 300 parts per million the cost figures would vary about in proportion to the hardness. Complete softening would probably be neither necessary nor desirable for municipal use, which would reduce the cost proportionately. For harder waters, the depth of the medium layer could be somewhat increased, sufficient probably to maintain rates of flow nearer the usual rates, without increasing the equipment except as to depth of the containers.